Mathematical Sequences of Connected, Cumulative and Challenging Tasks in the Early Years

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This symposium reports on a project that focused on *Exploring the Use of Mathematical Sequences of Connected, Cumulative and Challenging Tasks (EMC³*) with students in the early years (Foundation Level to Year 2). The project was funded by the Australian Research Council, Catholic Education Diocese of Parramatta and Melbourne Archdiocese Catholic Schools (LP180100600). Together with industry partners the EMC³ project was designed to enhance the cognitive and affective experiences of students when learning mathematics by researching teaching approaches that utilise sequences of cognitively challenging tasks.

Paper 1: *Exploring the Potential of Sequences of Connected, Cumulative and Challenging Tasks in the Early Years* [Peter Sullivan, Melody McCormick]

This paper outlines the rationale for the teaching approach the EMC³ project aimed at studying an approach to teaching and learning mathematics in the early years (students aged 5–9).

Paper 2: *Differentiating Mathematics Instruction through Sequences of Challenging Tasks in the Early Primary Years* [James Russo, Jane Hubbard]

This paper reports on post-program questionnaire data collected from 100 teachers who express their views about the effectiveness of various instructional approaches to support differentiation in mathematics.

Paper 3: *Changing Teacher Practices: A "Slow Burn" or Rapid with "Big Shifts."* [Sharyn Livy, Janette Bobis, Ellen Corovic, Maggie Feng]

This paper reports on interview data collected from five teacher educators who provided support to the teachers when trialing the EMC³ resources. The focus of this presentation will be on the notable changes to teacher practices.

Paper 4: *The Nature of Leadership and Other Support that Facilitate Innovation and Improvement in Teacher Practice.* [Ann Downton, Janette Bobis]

The final paper reports on survey data collected from 70 teachers about the forms of support that assisted implementation of project resources—in-class support and facilitation of planning.

2022. N. Fitzallen, C. Murphy, V. Hatisaru, & N. Maher (Eds.), *Mathematical confluences and journeys* (Proceedings of the 44th Annual Conference of the Mathematics Education Research Group of Australasia, July 3–7), p. 11–27. Launceston: MERGA.

Differentiating Mathematics Instruction through Sequences of Challenging Tasks in the Early Primary Years

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We report on questionnaire data gathered from teacher participants (n = 100) following their participation in the project, Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks. Teachers shared their views about the effectiveness of various instructional approaches to support differentiation in mathematics, including those illuminated through the project, and a description of a lesson involving effective differentiation.

Differentiating instruction in the context of mathematics teaching refers to the suite of strategies that teachers draw on to cater adaptively to the learning needs of heterogeneous groups of students, with the explicit aim of improving mathematical learning outcomes (Russo et al., 2021). Effective differentiation is acknowledged as a particularly demanding aspect of classroom teaching, with Shernoff et al. (2011) finding that "teaching large heterogeneous groups of learners" (p. 65) was the most notable student-related source of job stress for teachers, alongside "managing disruptive behaviour" (p. 64). There is further evidence that identifying and accessing appropriate learning tasks to meet the range of student learning needs is particularly challenging for teachers. For example, Gaitas and Alves Martins (2017) found that primary school teachers view the matching of activities and materials to the diversity of student characteristics, in relation to their academic readiness, interests and learning profiles, as the most difficult aspect of differentiating instruction effectively.

There is also evidence that without opportunities to develop further their pedagogical content knowledge, teachers may struggle to realise the differentiation potential of a given task. Bardy et al. (2021) found that German secondary mathematics teachers tended to be more focused on the surface structure of tasks (such as their layout) and less focused on the deeper design features (such as the adaptive features of the task), compared with mathematics task design experts. The authors concluded by noting that realising the full potential of a task, or sequence of tasks, to effectively support differentiation requires specific expertise and therefore targeted professional learning support for teachers. Despite its relevance to practitioners and implications for equity, the beliefs and practices about how teachers attempt to differentiate instruction by providing rich learning opportunities for all students remains insufficiently researched in the early years of schooling (Bobis et al., 2021).

We are currently involved in a research project, *Exploring Mathematical Sequences of Connected, Cumulative and Challenging Tasks (EMC^3)* (Sullivan et al., 2020). A key component of the EMC^3 project is a consideration of the extent to which teaching with sequences of challenging mathematical tasks supports differentiation in the mathematics classroom, through both low floor/high ceiling tasks, enabling and extending prompts, and purposeful tasks designed to consolidate learning after productive classroom dialogue about solution strategies. Importantly, given what we know about what teachers find particularly difficult in relation to differentiation (Gaitas & Alves Martins, 2017), participating teachers were provided with illustrative resources to support the implementation of the pedagogical approach, whilst also being encouraged to take an active role in the adaptation of the tasks, lessons and sequences to their particular context. The pedagogical approach presented to teachers in the EMC^3 project, including how it supports differentiated instruction, is elaborated on in Sullivan and McCormick (Paper 1, this symposium). The research questions we will briefly explore in this paper include:

2022. N. Fitzallen, C. Murphy, V. Hatisaru, & N. Maher (Eds.), *Mathematical confluences and journeys* (Proceedings of the 44th Annual Conference of the Mathematics Education Research Group of Australasia, July 3–7), pp. 16–19. Launceston: MERGA.

(1) To what extent do teachers view pedagogies promoted through the EMC^3 project as an effective means of differentiating mathematics instruction relative to other instructional approaches?

(2) How do EMC^3 project teachers describe their approach for differentiating mathematics instruction effectively?

Method

Participants in this study were Foundation to Year 2 (F–2) generalist Australian primary teachers who were involved in the EMC3 professional learning program during 2019 ($n = 100$). Teachers were introduced to the EMC3 approach during a full day of professional learning with the research team at the start of the school year. They were provided with sequences of challenging tasks and suggestions for their implementation. Support for enactment of the approach was provided to teachers through school visits from members of the project team. Participants also engaged in a second professional learning day in November of 2019. The purpose of day two was to provide teachers with an opportunity to share their post-program learnings and insights with teachers from other schools, as well as to consolidate their understanding around the instructional approach. Teachers were then invited to complete a questionnaire, including questions focussing on their beliefs and approaches for differentiating mathematics instruction. These data form the focus of the current paper.

Results

Perceived Usefulness of Instructional Approaches for Supporting Differentiation

Teachers were asked to indicate the degree to which they considered various approaches useful for differentiating mathematics instruction by responding to the prompt: *The following teaching approaches are useful for catering to students of different performance levels in the mathematics classroom*. For each of the approaches listed, participants recorded their response on a 7-point Likert-type scale, presented with two anchors (1-not at all useful; 7-extremely useful). Mean scores and the percentage of teachers' responses were calculated for each approach. See Bobis et al. (2021) for a more elaborate discussion of this data.

The data from the post-program questionnaire (Table 1) revealed that three teaching approaches were viewed by the majority of teachers as useful for catering to students of different performance levels in the mathematics classroom: problem solving—prompts; problem solving—low floor, high ceiling; and mixed game. These three approaches have important similarities. Most notably, they are the only three approaches of the eight listed that do not involve some form of a priori grouping of students according to perceived mathematical performance, whether such groupings take place within the classroom (grouped game; grouped rotations; grouped online; grouped worksheets) or between classrooms (fluid groupings). It is particularly encouraging that as many as 90% of teachers believed that differentiating problem solving tasks through students accessing enabling and extending prompts was a useful means of catering to different performance levels, with half of the teachers describing this approach as extremely useful. Such tasks formed the core of the learning sequences that teachers accessed as part of EMC^3, and the implication is that this approach was effective at allowing students of all levels to access the tasks. Our second research question focuses on how the teachers described effective differentiation.

Table 1
Usefulness of Approaches for Catering to Students of Different Performance Levels (n = 100)

Instructional Approach	Mean score	positive (5, 6, 7)	extremely useful (7)	not at all useful (1)
Presenting the whole class with the same core problem-solving task, differentiated through students accessing enabling and extending prompts*	6.12	90%	50%	0%
Presenting the whole class with the same core problem-solving task, differentiated through the task having a "low floor, high ceiling"*	5.65	83%	33%	1%
Playing the same mathematical game with the whole class in mixed-performing groups, with the game "naturally" differentiated through students using strategies of choice	5.55	83%	23%	1%
Playing the same mathematical game with the whole class in similar-performing groups, with the game differentiated through groups using resources matched to their performance level	4.36	46%	11%	3%
Between class performance grouping ("fluid groupings"), where similar-performing students are grouped together across classes and undertake activities that match their performance level	3.41	35%	3%	21%
Within class performance grouping, where similar-performing groups rotate through workstations undertaking activities matched to their performance level	3.27	28%	1%	21%
Allowing students to work through on-line activities/Apps at different levels of challenge, depending on their performance level	3.11	27%	4%	21%
Allowing students to work through worksheets at different levels of challenge, depending on their performance level	2.65	24%	4%	44%

*Instructional approach promoted through the EMC3 project

Teacher Descriptions of Effective Differentiation

Participating teachers (*n* = 94) responded to the following open-ended item post-program questionnaire prompt: *Think of a time in which you feel like you effectively catered to students of different performance levels in your mathematics classroom. Describe the lesson in as much detail as possible, including the structure of the lesson, the tasks and activities, your role as a teacher and what your students were doing.* Teacher responses were detailed, varied and extensive. From a mathematical content perspective, 69% of teachers specifically described a number lesson, 14% as a measurement lesson, and 9% as a geometry lesson. Some responses did not provide details for a particular content area but explained strategies for differentiation (9%). The majority of responses referred explicitly to lessons that were part of the EMC^3 project resources. Although all teachers implicitly or explicitly referred to using something that could be construed as an enabling and/or extending prompt to support their effectively differentiated lesson, three other notable themes that supported teachers to effectively differentiate instruction emerged: *the role of the teacher* (64%); *provisions to establish student agency* (53%); and *opportunities for peer learning* (48%).

The role of the teacher. The comments teachers made about their role in differentiated instruction reflect the active nature of teaching when supporting effective differentiation. To ensure learning remained student-centred, teachers described the ongoing adaptations and pedagogical actions deployed both in planning and during lessons to meet student learning needs. Many of these teacher actions to support individual student learning needs paradoxically

occurred at a whole class level. For example, teachers described how they made sure the task was set within a familiar context to support all students in comprehending the task and accessing the mathematics more readily. Other adaptations that supported all students included sharing students' work and prompting class discussions. Many teachers acknowledged that the use of open, prompting questions was helpful in initiating mathematically focussed discussions around the task. This included both general questions posed at a whole class level, as well as specific questions to target individual students.

Provisions to establish student agency. Teachers reported the different ways that students were afforded agency in how they approached the task, represented their thinking, and organised their solutions. The use of concrete materials, visual representations and recording templates were frequently mentioned as intentionally provided to support students in making choices as to how they communicated their thinking in meaningful ways. A different perspective on student agency encompassed comments that referred to class norms and consistent expectations that students persist when solving challenging tasks. Student friendly phrases such as "sweaty brain time" indicated a shared expectation that students needed to think for themselves and be willing to work hard to make sense of the mathematics.

Opportunities for peer learning. The data reflected widespread recognition of the role of peer learning when supporting differentiated instruction. Although reference to small groups and paired work featured throughout, orchestrating opportunities for class discussions were the more prevalent examples of peer learning. One frequently mentioned strategy was the use of "spotlights" to present student work for collective discussion during the explore phase of the lesson. Creating opportunities to share student work highlights how teachers draw on specific examples of student thinking to scaffold learning for the rest of the class. Sharing alternative strategies can support other students in considering alternative solutions, maintaining motivation, and/or consolidating learning.

Summary

Teachers viewed the pedagogical approaches emphasised through the EMC^3 project resources, particularly tasks differentiated through enabling and extending prompts, as more effective for differentiating instruction than other approaches. Moreover, teachers viewed effective differentiation in mathematics as being supported by several factors including: providing students with enabling and extending prompts; the teacher being in an active role during the lesson, facilitating adaptations to meet learning needs; providing opportunities for students to exercise agency; and adopting structures to support peer learning.

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